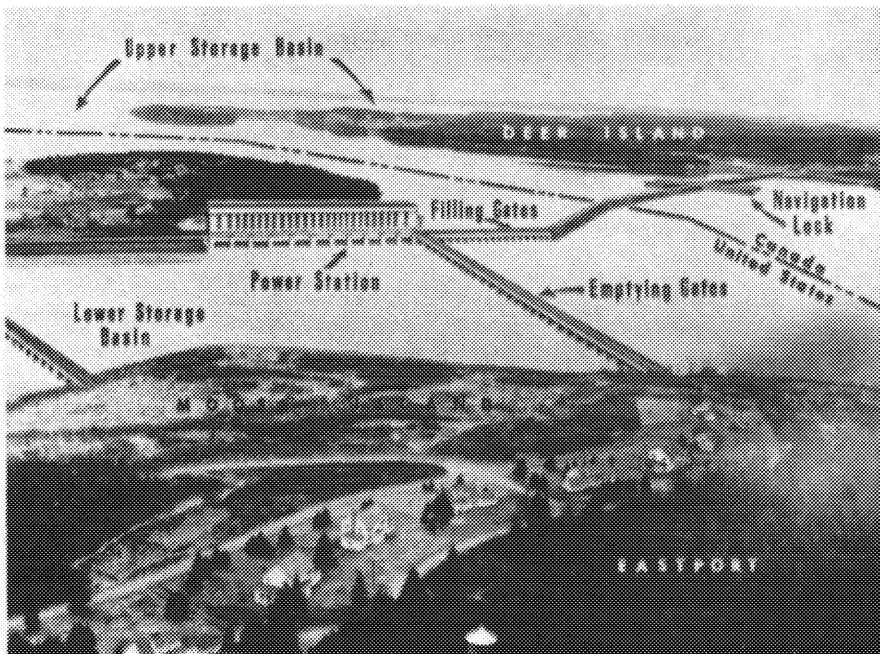
'PASSAMAQUODDY'



A NEW SOURCE OF ENERGY

Address by
Brigadier General Alden K. Sibley

ARMY-NED-BOSTON

U.S. Army Engineer Division, New England
Corps of Engineers
Boston, Mass.

PASSAMAQUODDY: A NEW SOURCE OF ENERGY

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PASSAMAQUODDY: A NEW SOURCE OF ENERGY

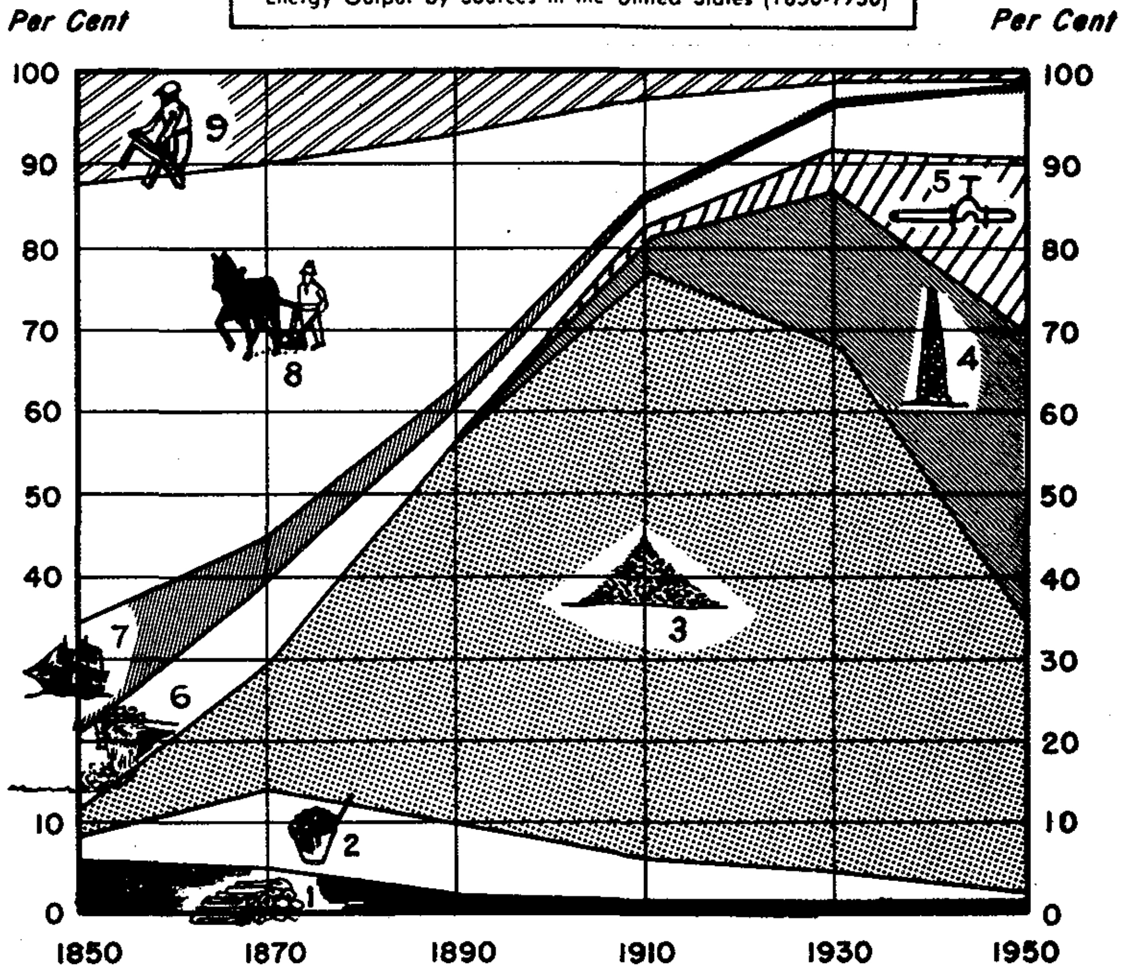
This evening I want to talk to you about a potential new source of energy: The Passamaquoddy Tidal Power Project. But before we take a look at the progress of the studies now going on up in the Cobscook in Quoddy areas of the Bay of Fundy, let's turn our attention for a moment to the problem of energy sources in a larger picture: the problem of our future sources of power. In this way, we can perhaps arrive at a better understanding of the significance of harnessing the ocean tides as an additional new source of energy.

We all learned in high school that the center of our little planetary system, the sun, which the astronomers class as a medium-sized Grade G star, is the source of all life and of all forms of energy on our planet. This, of course, is something of an over-simplification, for there is one other source of energy that comes not from the sun's heat, and that source is the moon. Although cold and lifeless, the moon's proximity to the earth results in a tremendous gravitational pull on the earth. It is this moon energy that the Passamaquoddy tidal plant could harness.

Besides harnessing our rivers and streams for hydraulic power, conventional sources of energy rely upon unlocking by chemical combustion the sun's energy that was stored in fossil fuels - coal and oil - millions of years ago. With the advent of the nuclear age, with the explosive proof of Einstein's formula $E = mc^2$, which postulates that mass and energy are simply different manifestations of a single entity, we now find that we are able to unleash, through the processes of fission and fusion, the energy stored from the beginning of time in the very building blocks of the universe itself: the atom. A third great source of energy relatively undeveloped by man thus far is that of the rise and fall of ocean tides as the moon swings around us. How to develop all these sources of energy will be of great import to all of us in the coming years. Indeed, upon our genius and ability to tap all possible energy sources to an extent never dreamed of fifty years ago will rest our very survival as a nation.

As you can see from Chart I, the sources of energy in the United States have been in a constant state of flux over the past 100 years. The top of the chart represents 100% of the energy consumed. And the sources of this energy are shown by the curves beginning with wood energy at the bottom, anthracite coal, bituminous coal which peaked in 1910, oil which was negligible before 1890, gas which came in even later, hydro power which decreased to a minimum early in this century and is now expanding, windpower, horsepower and manpower, all three of which have petered out to practically nothing. It is interesting that in 20 years the 70% to 30% ratio of

Energy Output by Sources in the United States (1850-1950)



1 Fuel Wood
2 Anthracite
3 Bituminous Coal
4 Petroleum
5 Natural Gas
6 Water
7 Wind
8 Work Animals
9 Human Workers

1953 Annual Report of the Twentieth Century Fund

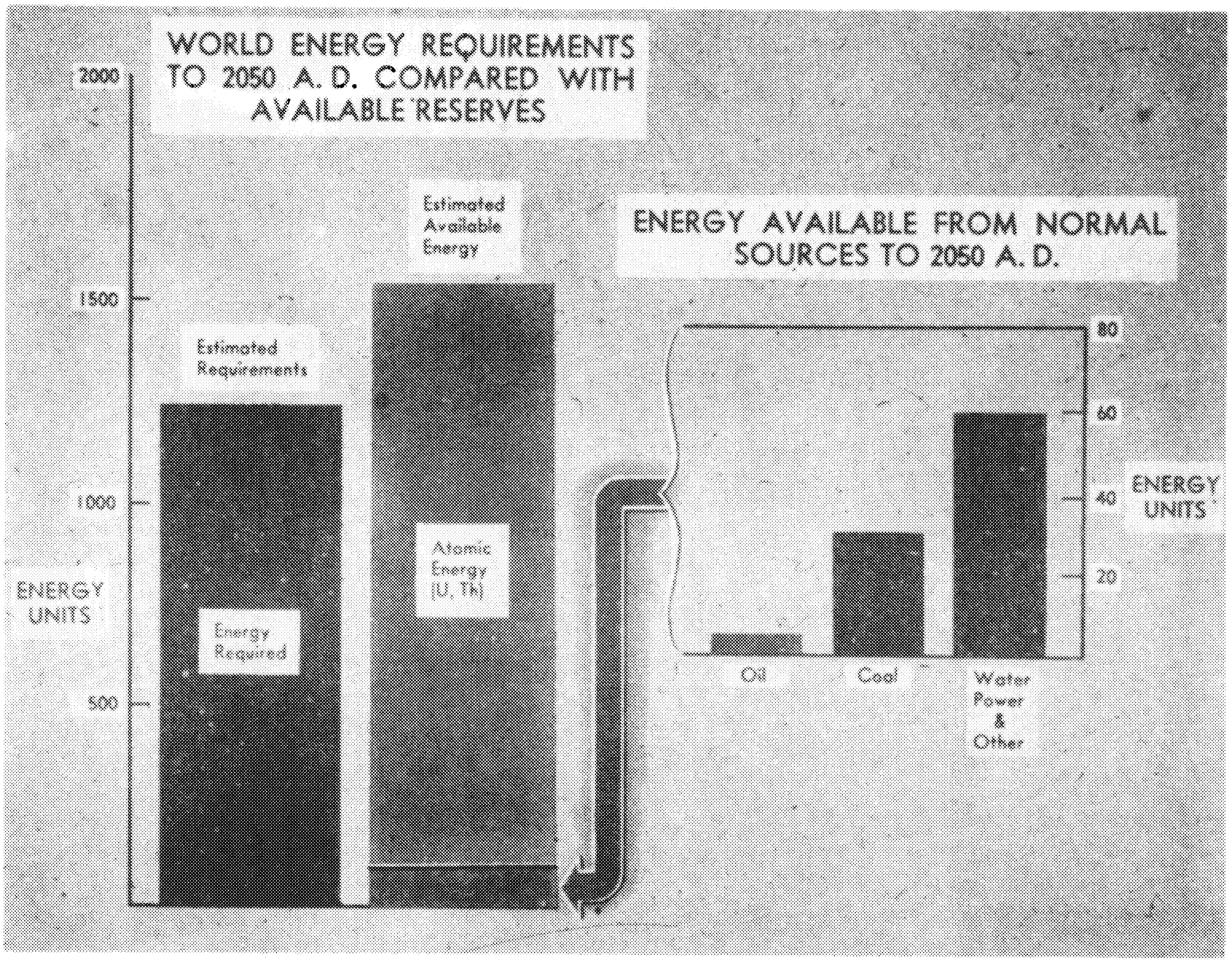
CHART I

coal to oil and gas in 1930 had almost exactly reversed itself by 1950. But the age of plenty in fossil fuels is drawing to a close.

How much energy will we need in the next 100 years, and where will it come from? When we realize that today's Soviet strategic plans, like stock market trends, are educated guesses of tomorrow's conditions, this next chart (#2) is a frightening picture. On the left we have world energy requirements estimated for the next 100 years. On the right are shown at an exaggerated scale, the total amounts of energy available in the world from all normal sources. When compared to requirements and reduced to this same scale, all normal sources of energy will yield less than one-tenth of the world's requirements over the next 100 years. This does not mean that all the world's conventional energy resources will be exhausted by 1967 because our requirements' curve is roughly exponential. It does mean, however, that at the average rate of predicted energy consumption in the next 100 years, less than a 10-year supply is available from known conventional sources in the world. And if we are prodigal in burning up our fossil fuels for energy, there will be none left for the vital chemical processes on which we have come so largely to depend.

But this is only part of the picture. A few pioneering and Federally subsidized industries are building nuclear power plants in this country and abroad. Coal-hungry England, whose 12 mill

CHART 2



Source: A. C. Montieth, Westinghouse Electric Corp nuclear power is economically competitive with thermal power, has crashed her program to nuclearize 60% of her power industry by 1965; the United States, on the other hand, burning up her fossil resources at 8 mills per kilowatt-hour, lags far behind in nuclear power. When we do seriously tap these resources, however, the world's known deposits of uranium and thorium are adequate to see us through the next 100 years with a little to spare. But what then? With the immediate possibility of exhausting our fossil fuels as a source of energy, and with a definite limitation of our uranium sources facing us, man must look to other sources. Where should he look? When faced with such a dilemma, man's age-old solution has been to look to the heavens. This solution may serve us here.

Recently, a German-born astrophysicist, Hans Bethe, now working at Cornell University, solved the mystery of the source of the sun's energy. He showed how the energy radiated from the sun comes from the burning of hydrogen atoms into helium. At Eniwetok in the spring of 1951, physicists Norris Bradbury and Ed Teller made enough heat with an ordinary atomic fission explosion to burn a container of hydrogen isotopes into helium for the first time on earth. But the intense heats of the atomic explosion which succeeded in fusing the light elements of hydrogen lasted only a fraction of a microsecond. The problem of sustaining heats and pressures of these magnitudes seemed almost unsurmountable on earth. Thus, the problem of a sustained thermo-nuclear reaction for the production of useable energy remains one of the most challenging facing the nuclear physicist today. Sir John Cockroft in London has undertaken a program to see whether a controlled fusion reaction can be maintained within the walls of a magnetic field, thus turning the fusion reaction in on itself, and thereby successfully tapping a source of energy so vast it staggers the imagination. Faced with the possibility of fossil and uranium fuel exhaustion, this sustained thermo-nuclear reaction may well be the solution to our energy needs, if western scientists are successful in perfecting the nuclear-fusion process.

But what other possibilities may appear as we turn our eyes toward the heavens? Our natural sputnik, the moon, exerts tremendous energy on earth. The most common manifestation of this energy is that of the tidal movements of our oceans. What about harnessing these tides as an added source of energy in a time in our history when the need for energy has never been so great, nor the exhaustion of our conventional sources of fuel been so imminent? Research of potential tidal-power sources should be conducted to make sure that no source of additional power has been overlooked.

An approach to the solution of the problem is clearly defined for us. We must be willing to develop those ideas to constructive conclusions that will enable us as a nation to meet our energy requirements in order to survive. We must think and think hard, and most especially in those fields which you have chosen for your major academic work.

You are all well aware of the strides being made in science and engineering in the Soviet Union. Our efforts in these fields must be superior in both quality and quantity where effort is needed to preserve our national security and secure a foundation on which further scientific advances may be made. We can leave no stone unturned, no possible source of additional power uninvestigated. Obviously there is a great need not only for the applied scientist but the contemplative one as well, and my hope is that more of the engineering students throughout the country, like yourselves, will find their way into theoretical activity in science and engineering, much as Dexter P. Cooper did when he envisioned the possibility of harnessing the tides of the Passamaquoddy and Cobscook bay areas.

However, before we turn our attention to the plans developed to harness the tides of Passamaquoddy and Cobscook Bays, perhaps you can bear with me while I run through a brief and simplified review of the sun - earth - moon relationships and resulting gravitational effects upon the earth's oceans. To simplify the theory, let us suppose, as Newton did, that the earth is covered by a uniform envelope of very deep water. Since gravitational attraction between two bodies decreases as the square of the distance between the bodies, the moon attraction is accordingly more than average for that part of the ocean nearest the moon and less than average for the most distant part. Thus the ocean has the shape of a football or prolate ellipsoid of revolution, whose longest axis would be directed toward the moon if additional effects were absent. This water football tumbles slowly eastward end over end, following the moon in its monthly revolution around the earth. Meanwhile the earth is spinning eastward rapidly inside the water football; it makes a complete rotation relative to a particular point on its football envelope once in a lunar day, which averages 24 hours and 50 minutes. At any given point, high tide occurs at intervals of 12 hours and 25 minutes, and low tide at equal intervals halfway between. However, the ocean is not deep enough to fulfill our assumed condition and, moreover, the earth's rotation is too rapid for this simple theory to apply; and other factors which have important effects - presence of land masses and effects of harmonic resonance - have not been taken into account. High tide and the transit of the moon are generally far from simultaneous.

Then we have the sun, which also causes tides in the ocean. Because the tide-producing force of a body varies inversely as the cube of its distance, the sun, despite its enormously greater mass, is less than half as effective as the moon in raising tides on earth. The two sets of tides may be considered as operating independently, the relative positions of their crests varying with the phases of the moon. The spring tide occurs at new and full moon. Since the moon and sun are then attracting at the same or opposite directions, lunar and solar tides reinforce each other. Neap tide occurs when the moon is at either quarter phase, when the moon and sun are 90 degrees apart, so that one set of tides is partly neutralized by the other. When the moon is new or full and also in perigee - the point in the moon's orbit closest to the earth - the change in level between low and high tides is especially great.

Far out to sea, the water surface merely rises a little and then subsides again as each tidal bulge passes; but where this bulge impinges against a coast the water is dragged forward, piling up on the shore and then receding. The height the tide will reach is largely determined by the configuation of the coast. On open, exposed coasts it is not more than 6 or 8 feet, and in nearly land-locked embayments such as The Gulf of Mexico it is only 1 or 2 feet. In estuaries that open out toward the advancing tide, however, the water piles up as it is crowded forward into the ever narrowing bays, setting up strong tidal currents. This brings about exceptional conditions, such as those in the Bay of Funday, where the highest tides in the world are found.

To return to our main theme then, it is axiomatic that where the tides are the highest, the potential power source is greatest. As you can see from the map (Chart 3) the Passamamaquoddy and Cobscook bay areas are located adjacent to the Bay of Fundy, in an area partly in the United States and partly in Canada.

In the Passamaquoddy area the tidal range is 50 feet from low tide to high tide, at the head of the Bay of Fundy. Passamaquoddy tides range from about 11 feet at neap tide to 26 feet at spring tide. About four billion tons of water flow into and out of Cobscook and Passamaquoddy Bays twice each day. This volume of water is equivalent to the average flow of nearly two weeks of the Mississippi River below the mouth of Red River, representing the accumulated runoff from almost half of the total 3,000,000 square-mile land area in the United States.

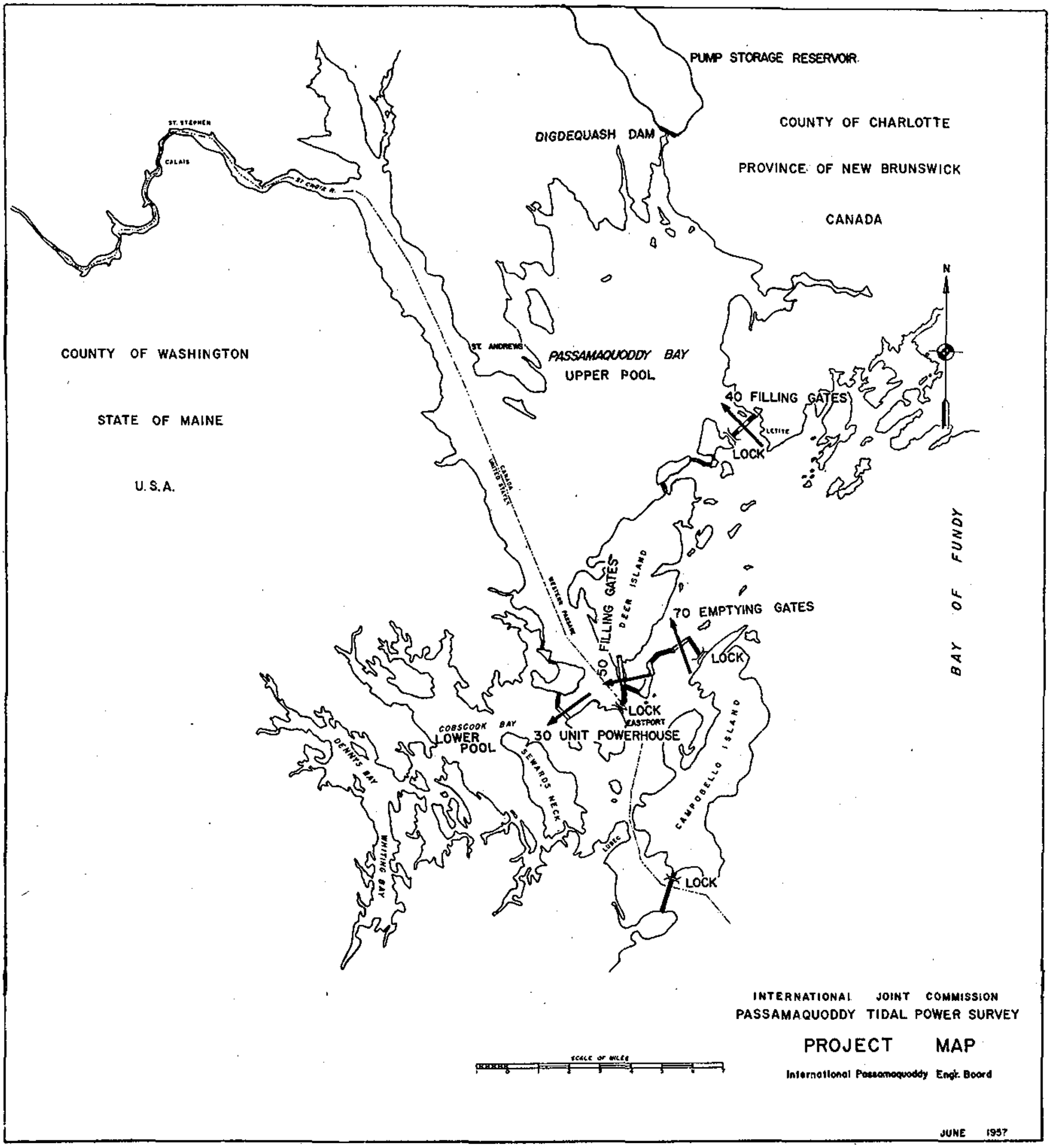

PUMP STORAGE RESERVOIR
DIGDEQUASH DAM
COUNTY OF CHARLOTTE
PROVINCE OF NEW BRUNSWICK
CANADA
ST. STEPHEN
CALAIS
ST. CROIX R.
ST. ANDREWS
PASSAMAQUODDY BAY
UPPER POOL
COUNTY OF WASHINGTON
STATE OF MAINE
U.S.A.
40 FILLING GATES
LOCK
LETITE
CANADA
UNITED STATES
DEER ISLAND
50 FILLING GATES
70 EMPTYING GATES
LOCK
BAY OF FUNDY
LOCK
EASTPORT
COBSCOOK BAY
LOWER POOL
30 UNIT POWERHOUSE
DENNYS BAY
SEWARDS NECK
CAMPOBELLO ISLAND
WHITING BAY
LUBEC
LOCK
N
SCALE OF MILES
INTERNATIONAL JOINT COMMISSION
PASSAMAQUODDY TIDAL POWER SURVEY
PROJECT MAP
International Passamaquoddy Engr. Board
JUNE 1957

CHART 3

Even if only a fraction of this great volume of water could be used to drive turbines, the resulting power would be impressive. In addition, harnessing of these tides could produce an unending source of power, a source unaffected by droughts, floods, or ice-jams.

Tidal power, basically the same as any other hydro-power production, is produced by passing water from a higher to lower elevation through hydraulic turbines. Tidal hydroelectric power can be produced by storing water in a controlled basin at high tide and releasing it through turbines back into the ocean as the tide recedes.

At present there is underway a joint investigation by the United States and Canadian Governments to see whether a project in the Quoddy area is economically feasible. Nothing I may say today should be interpreted as pre-judging the results of this three-year study, which, now one year under way, will determine the feasibility of construction.

Some sixty different engineering arrangements have been considered. A typical arrangement, as shown on Chart 3, would be to block the seaward entrances of Cobscook and Passamaquoddy Bays with large dams, thus connecting the islands to the headlands and providing for each bay an impregnable barrier to the sea. Among the plans considered was the "one pool" scheme, in which water is stored in a controlled basin at high tide and released through water wheels at low tide. This plan had a major drawback, however, because for about 2 1/2 hours between high and low tides the lack of head would necessitate a power plant shutdown. Thus, no power could be generated for about five hours each day. While this was sound from an engineering point of view, it was economically infeasible. Usable power output must be constant - 24 hours a day. To solve this problem the "two pool" scheme, which is presently under investigation, was developed. One pool in this plan is filled at high tide and kept at a relatively high level, and the other pool emptied at low tide and maintained at a lower level. Power is produced by releasing water from the higher pool through turbines to the lower pool, thus producing a continuous generation of power.

The first large scale study of the potential power production in this area was made in the early 1920's. Several other studies have been made since then, concluding that the development of a two-pool project could be physically engineered and operated, although information sufficient to determine its economic feasibility was yet to be obtained.

Congress has authorized the expenditure of $3,000,000 for a comprehensive study of the Passamaquoddy project. Under the jurisdiction of the International Joint Commission, an Engineering

Board comprised of two engineer members from Canada and two from the United States was appointed to supervise the study. General Samuel D. Sturgis, who recently retired from active service as Chief of Engineers of the U. S. Army, represents the United States as Chairman of the U. S. Section, while the U. S. Army Engineer Division, New England, has the assigned task of carrying out the engineering phases of the investigations. The Federal Power Commission is also participating with my office in conduct of studies to determine the potential market for power produced in the Passamaquoddy area. An International Passamaquoddy Fisheries Board was constituted to determine the effects which the construction, maintenance and operation of the tidal power structures proposed might have upon the fisheries in the area.

The two pool scheme appears to be the most feasible arrangement in terms of constant power production. One phase of the investigation centers around the problem of locating the two pools so that the maximum amount of power is produced at the lowest cost. Another factor to be determined by the International Joint Commission is that of deciding which project layout is most desirable from the standpoint of public interest. This means that the project arrangement as finally determined does not have to be the one that will produce the cheapest power if other public considerations are of sufficient importance. Nevertheless, the cost of power derived from the adopted scheme must compete with the cost of power from other sources.

A question that has probably already occurred to you is how much power will be developed in the best arrangement. The factors we are considering in answer to this question are:

1. The combined area of the two pools.
2. The ratio of the areas of the upper and lower pools.
3. The number of power-generating units.
4. The number of filling gates.
5. The number of emptying gates.

Thus every project arrangement and every variation in number units or gates that is studied requires a calculation of the power produced. The most efficient arrangement will be found in this way. As you well know in relation to your own studies, the more thorough and detailed a study, the more accurate the conclusions. This is precisely what we are attempting to do here.

Mathematical calculations of power output from the two-pool scheme are being made on electronic digital computers. The General Electric Company's IBM 704, affectionately known to its operators as the "high-speed moron," is saving us a vast amount of time and money by rapidly solving the highly complex problems of calculating kilowatt output from a number of alternate power-unit arrangements within the two-pool scheme in our efforts to find the system which will give us maximum power at lowest cost.

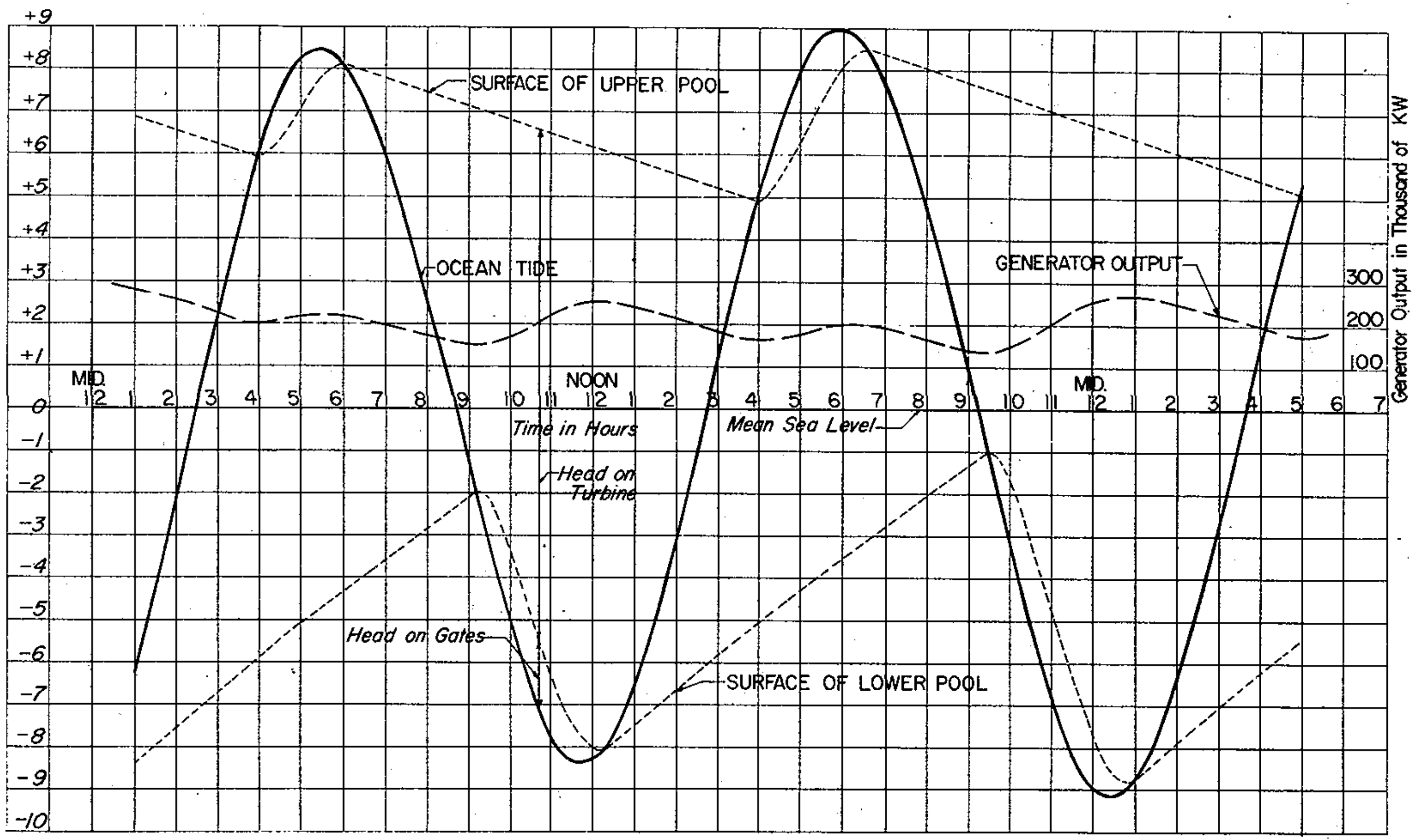
Working at the rate of 40,000 computations a second (with no coffee breaks), the "704" can compute the power output for one full month's operation in 4-1/2 minutes. It would take one engineer, or mathematician, employing somewhat less accurate methods, a total of 15 days - 120 hours - to do the same amount of work. Even at $11 per minute for computer time, the "704" comes up with the right answers at a great saving in costs.

Briefly, the kind of power problem fed into the computer is a gigantic math problem, which takes into account variations in tidal cycles, pool area and depth curves, hydraulic equations of filling and emptying "head" losses at the gates, and power output curves of a complete cycle of flow from the upper pool to the lower. The problem is to figure out what the power output will be under any given arrangement of dams and various turbine locations.

Hydro power is, of course, a function of the continuously changing head at each turbine. Average annual project output is calculated by determining the power capability of this continuously changing head by calculating first the kilowatt output at 15 minute intervals, multiplying by that interval to obtain energy produced in that interval, and summing up the result for total energy. A print-out made by the machine from a magnetic tape shows time, ocean elevation, upper and dower pool elevation, kilowatt hours produced in the interval, and accumulated kilowatt hours.

Since our studies are yet far from complete, an indication of the power potential of the Passamaquoddy Project may be obtained from Dexter Cooper's original studies. He estimated that his initial installation would annually produce 1.5 billion KWH and his ultimate installation 2.4 billion KWH per year. Under any scheme, however, the factor of varying power output that ranges from 150,000 KW to roughly 300,000 KW makes the project by itself inefficient in serving a normal industrial load (see chart 4, Typical Cycle of Tidal Plant Operation).

How then can the enormous potential energy of Quoddy best be utilized? There are a number of ways this can be done.



INTERNATIONAL JOINT COMMISSION
PASSAMAQUODDY TIDAL POWER SURVEY

TYPICAL CYCLE
OF
TIDAL PLANT OPERATION

International Passamaquoddy Engineering Board
UNITED STATES   CANADA

Date: Dec. 1957   Dwg. No. TUO-016

CORPS OF ENGINEERS, U.S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASSACHUSETTS

CHART 4

First, Quoddy power could be fed into a system or systems of sufficient size and load demand to use all the Quoddy energy as it is generated and regulate or supply the additional power demands from the sources in the system.

Second, an auxiliary source of power might be developed to supplement Quoddy power output at its low points. In this case, energy developed from adjacent rivers could be used. A river power plant of this sort would be designed for a rather low load factor.

Third, Quoddy power could be supplemented by means of a pumped storage plant, the operations of which resemble the functions of a car battery. Instead of storing electrical energy, however, potential energy in the form of water could be stored at a higher elevation. This water would be pumped to the higher storage basin using power from Quoddy at times when it is not required to meet load demands. When load demands exceeded the output available from Quoddy, this water would be released through turbines and power generated as required. There are three sites in the Passamaquoddy Bay area that appear suitable for development as pump storage plants, and there are other locations that would be available after construction along the transmission system.

The final cost estimate of the Passamaquoddy is not known, but one of the major factors being considered is the amount of material needed to construct the dams or barriers across the ocean passages to form the retention basins. By means of test boring and fathometer sounding we can map the bottom of the ocean and the top of the rock underlying the overburden. In some locations the water is 300 to 400 feet deep; overburden in some spots is over 200 feet thick. An engineering study of the various dam sites is under way to determine whether this overburden will support high rock-fill dams. If it will not, then the extent of foundation failure and its effect on dam quantities must be determined through soil tests.

Early in the investigation of possible site locations, a contract of about $500,000 was let to a Texas contracting firm to obtain the necessary soil samples by test borings from which to draw conclusions about site suitability. It has been so far the most interesting and largest single operation in the survey. Drill holes in deep water were made in likely locations for dams. Some of these drillings were made in currents as fast as 5 knots, and when the top of the overburden was 300 feet below mean sea level. The drilling contractor employed equipment like that used in oil drilling in the Gulf of Mexico.

Although quick changes in current and tidal changes created operating problems, undisturbed soil samples of overburden and rock were successfully secured.

Equally as challenging was the use of highly specialized sonic fathometer equipment used in correlation with the highly expensive test borings. A joint investigation by the U. S. Geological Survey and the New England Division of the Corps of Engineers in the summer of 1951 established the applicability and reliability of "sonar" soundings by comparing sonic data with boring data obtained in the water areas between Eastport and Lubec by the Corps of Engineers in the 1935-36 surveys.

Sonic explorations employed a special high-powered, low-frequency fathometer called a Sonoprobe, developed by the Magnolia Oil Corporation of Dallas, Texas. The 1951 survey had two objectives: (1) to test the effectiveness of sonic methods for determining distribution and thickness of unconsolidated sediments within some 130 square miles of pool area; and (2) to discover as much as possible about such sediments in Passamaquoddy Bay. An operation such as this required solution to a vast number of complex problems. Accurate vertical and horizontal control of the sounding depths must necessarily be referred to existing water elevations, and this problem was compounded due to the swift tidal currents and large tidal variations in Passamaquoddy Bay. Water-temperature gradients had to be accurately recorded. Since, as you know, the speed of sound increases rapidly with increased temperature and density, sounding in water depths up to 500 feet must be adjusted to these changes to be accurate. Data for such adjustment was obtained with a small torpedo-like device with a long name - a bathythermograph. Similarly, since these low frequency soundings were used to determine depths of overburden - of sediment layers above bedrock - the speed of sound through the increased density of the overburden had to be determined by comparison with a test boring. Shown as a permanent record, then, on the sound recorder (burnt into chemically treated paper as a current passes through it from the stylus) were recorded three marks: (1) the initial impulse; (2) an echo of the top layer of sediment; and (3) a fainter echo from the bedrock beneath. By this method we were able to cut sharply the cost of bottom and foundation explorations by supplementing judiciously chosen test borings with fathometer data. Conversely, optimum points for physical test borings were determined by a preliminary sonic survey.

Results of other studies that will be included in the final report on Passamaquoddy will be:

1. Location of suitable materials for construction of the dams and for concrete aggregates.

2. The most economical and practicable construction method for the dams.

3. The design of the locks.

4. The most efficient hydraulic system.

5. The structural design of the emptying and filling gates and

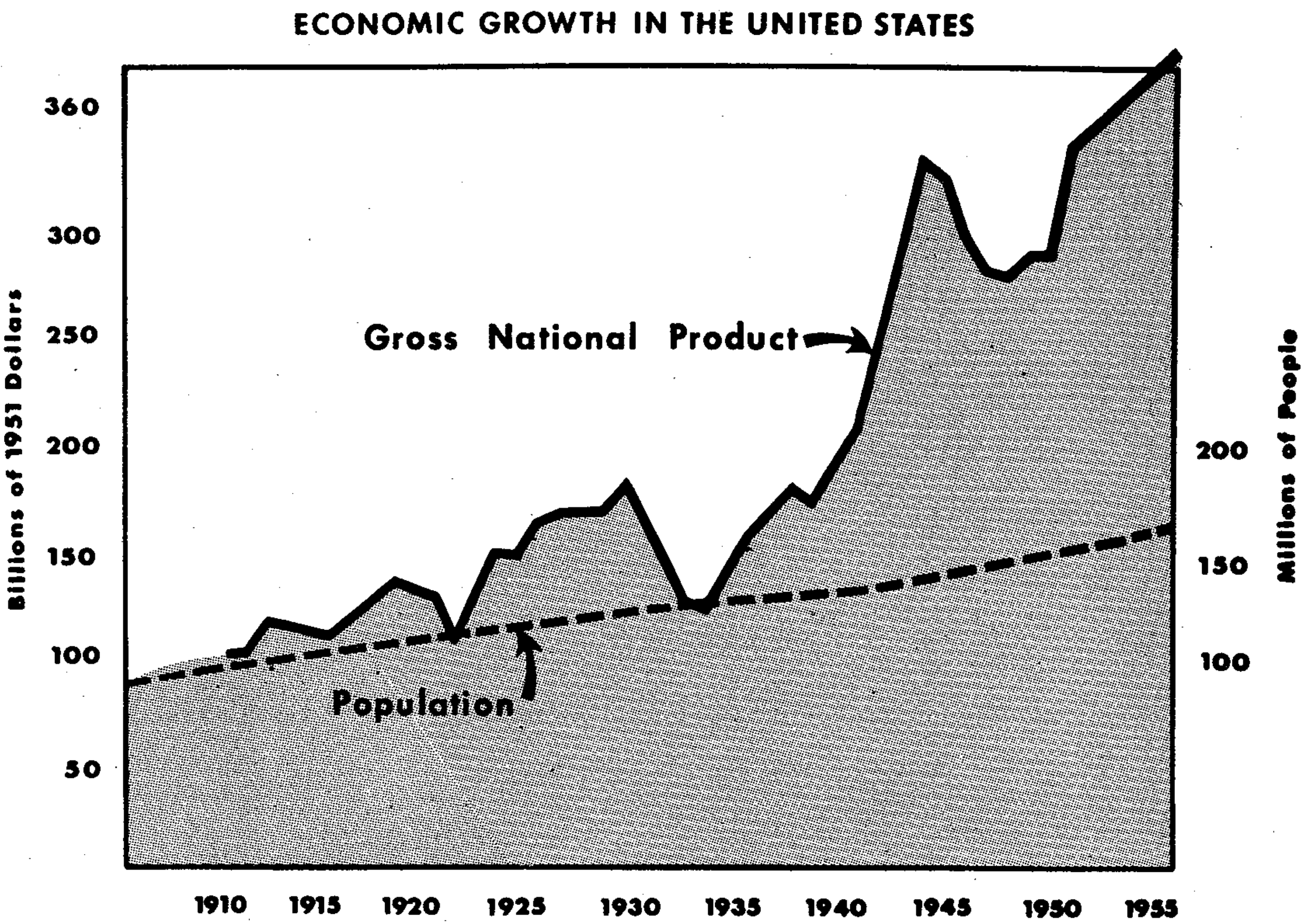
6. The power plant.

In elaborating a bit on point No. 6, the power plant, consideration is being given to a new type of turbine recently developed in Europe and which has been adopted for use at the LaRance River Project in France. The LaRance tidal power project is in a stage of advanced planning and will use in construction a turbine positioned horizontally in the water passage with the generator enclosed in a water-tight compartment in front of the turbine. These power plants, called bulb type units, are claimed to produce a more economical installation than conventional units. In connection with the survey, however, all types of turbines are being investigated; the conditions which made the bulb type unit the most desirable in the interconnected French electrical power system may not make it at all desirable for use under the conditions found in eastern Maine and New Brunswick.

Although the potential power source of the Passamaquoddy tides represents but a tiny fraction of the great power pool that we must have if we are to survive as a nation, attempts to produce economic, useable power from harnessing ocean tides have implications of much greater magnitude. The Passamaquoddy project symbolizes the constant search for new sources of power, a need which is the very basis of our future security. If we are to attempt to answer the burning questions of the age: Will there be another war? If so, when? What will it be like? How can we avoid another war? If war comes, how can we prepare for the defense of our lives and liberties? We must educate, we must think, think hard, think until it hurts. Times and values and the challenge to an individual and his education are changing rapidly. To paraphrase Henry Adams, a noted poet-architect of the latter 19th century, a genius is a person able to see the significance of what appears to be irrelevant by relating for example, accomplishments in science to an understanding of human relations. Our age must be characterized by men of tremendous accomplishments in all fields with the ability to relate their work to the works of others, and to the security of our country.

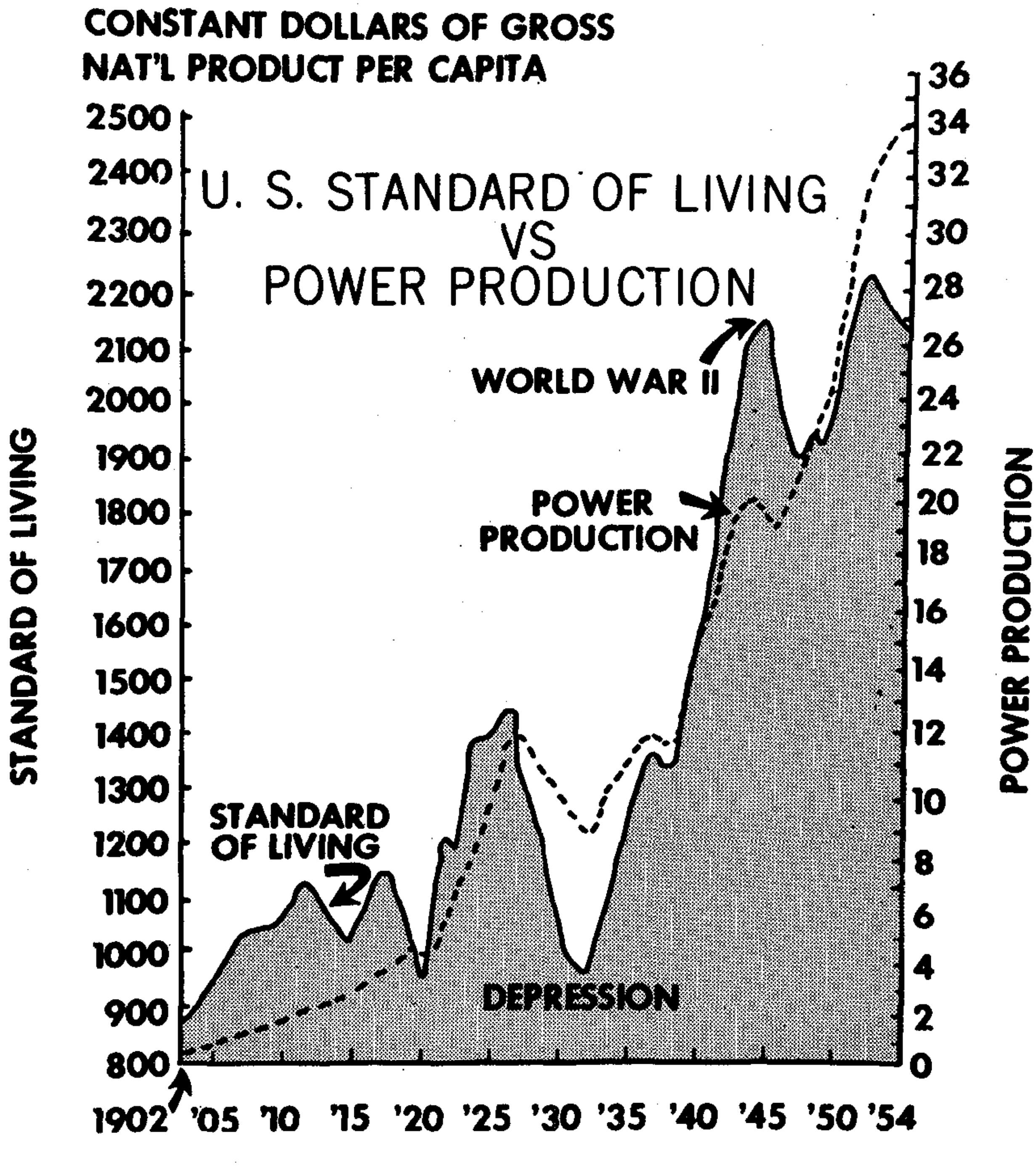
If there are to be wars of the future, for what will they be fought? Assuredly they will be fought for something man holds priceless, something for which he is willing to give his life and risk the lives of others. Wars of the past have been fought for gold, for land, for glory, for blondes and brunettes for that matter. Wars of the future will be fought to control the earth's energy resources.

In 1910, our 100 million people produced 100 billion dollars worth of goods and services (Chart 5). Our gross national product, which in a sense reflects our standard of living, has shot up out of all proportion to our population growth until last year it hit the $400 billion mark. Extended, the curve is roughly exponential while the population curve shows only an arithmetic increase. What does this mean? Surely it means that we would not willingly return to a 1910 economy. We would probably fight to avoid doing so. But on what foundation does this exponentially expanding $400 billion standard of living rest? If we plot this same curve as per capita GNP (Chart 6) we more closely approximate the growth of our standard of living. Startlingly enough, if we quite independently plot our per capita power production in kilowatt hours per man per year, over the same time period, we find a very close agreement between the shapes of the two curves. The significance is evident; our priceless heritage of social and economic progress is irrevocably tied to the consumption of energy in ever increasing amounts. The Paley Commission appointed by President Truman



SOURCE: *Industrial College of the Armed Forces*

CHART 5


CONSTANT DOLLARS OF GROSS
NAT'L PRODUCT PER CAPITA
U. S. STANDARD OF LIVING
VS
POWER PRODUCTION
WORLD WAR II
POWER
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OF LIVING
DEPRESSION
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1902 '05 '10 '15 '20 '25 '30 '35 '40 '45 '50 '54

CHART 6

in 1951 concluded that American power needs could be expected to double within the next twenty-five years. But it has already increased by half in less than a quarter of that time. The Federal Power Commission - a relatively conservative body judging by its past predictions - now expects our use of power by 1980 to be four times our present consumption. This would conform to practically an exponential rate of increase if we extrapolate this curve. In ten, fifty or one hundred years, to maintain our progress which we have come to think of an inherent in the American way of life, we shall evidently need to consume a staggering amount of energy.

On the horizon are solutions to our energy problem. Already a commercial atomic power plant is operating in Shippingport, Pennsylvania, to supply the City of Pittsburgh with electrical power. Already major efforts of our finest mathematicians and scientists are focused on controlling a thermonuclear reaction for industrial use. We have an H-bomb but as yet no H-furnace. Whether we shall achieve a controlled thermonuclear reaction for industrial use in the next 50 or 100 years we do not know for sure. Therefore, the development of all possible sources of energy must be encouraged in order for us to maintain the energy-power base that means economic plenty, and in turn gives us a sound foundation on which to base our plans to insure our national security. Our power problem presents a challenge to think, a challenge to create and implement ideas that will meet the energy problem head on. Recently in a Soviet publication the following was written:

"The creation of the earth's first artificial satellites was a natural link in the chain of achievements in science and engineering in the Soviet Union. To recall Russia forty years ago is to gauge the magnitude of this achievement. It telescopes the tremendous changes which have taken place in the way of life of an entire nation.

"Education was a key which unlocked the door to a veritable treasure house of talent that had lain dormant. Two generations have produced an army of engineers and metallurgists, chemists and electronic engineers, physicists and mathematicians capable of working out all the intricate problems connected with launching an artificial earth satellite, and a highly developed industry ready to produce the most complicated apparatus their thinking could conceive."[1]

In the last two years twenty percent of Russian engineering graduates are fundamental researchers: pure physicists, mathematicians, and chemists. Perhaps the Russians are wrong

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1 USSR - #15 - Published by the Embassy of the Union of Soviet Socialist Republics in the USA.

in such a concentration as this. If they are wrong, they will have an overabundance of both applied and pure scientists. If we are wrong in developing too few scientists in both these categories it may cost us our survival as a nation. We must find some way to alleviate the shortage of pure scientists in the country. Some sort of incentive must be supplied to the young scientist to make a rewarding future in the laboratories of fundamental research. Tragically in our country the road to economic success and the presidencies of corporation leads not through the laboratory. A mathematician to be economically successful by American standards must forget mathematics, learn to sell soap, buy a house near the country club and drive two cars. Otherwise, he is a square, a queer sort of a nonconformist whom "normal" Americans may secretly suspect.

In Soviet Russia a young man or woman who attains distinction over intense competition in mathematics or science automatically becomes a member of the economic and social elite. Concessions by the State, fringe benefits and incentive awards place him in a kind of socialist aristocracy where he maintains his place by his mental fertility - his production of ideas.

We as engineers can help improve the lot of our meager and devoted corps of career thinkers in American by understanding and appreciating them, and by our readiness to apply the fruits of their contemplation to our own fields of technological development. We can encourage them, and work to see that those broad economic incentives are provided which can inspire the young minds of our country to meet the challenge of the nuclear age - the challenge to think. For I say to you with all the strength and will at my command, in this era of politico-military tension, nuclear plenty and world-circling satellites, young Americans must learn to think or learn Russian.